FOREST PRODUCTS

Project Fact Sheet

Development of Corrosion-Resistant, Chromium-Rich Alloys for Gasifier and Kraft Recovery Boiler Applications

Benefits

- Increases recovery of the energy content of black liquor
- Enables commercialization of black liquor gasification technology
- Enhances energy independence of mills

Applications

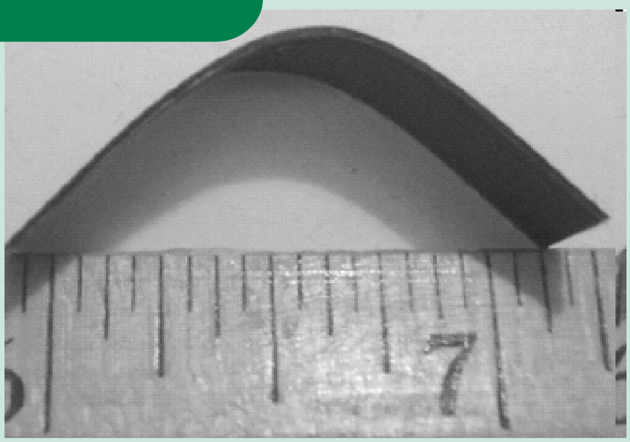
At present, there are 100 Tomlinson boilers in use in the United States. Many will need to be replaced or extensively rebuilt in the near future. Gasification systems could be installed in place of essentially all of these units, which would implement the new technology and improve the efficiency of the mills. It is anticipated that the new alloys could be applied in both recovery boilers and biomass gasifiers.

New Materials Are Needed To Withstand the Environment of Molten Smelt

The production of pulp and paper by the kraft process requires efficient recovery of chemicals and energy from the black liquor produced in the pulping process. Burning the black liquor in a Tomlinson boiler has been the traditional method for disposing of the organic waste, recovering inorganic chemicals, and producing electric power for the mill. When used in a combined-cycle mode, black liquor gasification represents a more cost-effective and efficient alternative to recovery boilers, and can potentially satisfy all the energy needs of the mill. However, numerous materials-related issues became apparent during pilot-scale testing of black liquor gasification. Most pressing is the need for alloys and coatings that can withstand the extremely corrosive nature of smelt, the molten alkali salt byproduct of the burning of black liquor. The new materials are needed for components ranging from thermowells and brackets to spouts and structural components. Such alloys would improve the efficiency of recovery boilers and biomass gasifiers, enabling the successful implementation of gasification technology.

Preliminary studies conducted at Oak Ridge National Laboratory (ORNL) have suggested that new chromium (Cr)-rich alloys exhibit at least seven times more corrosion resistance than the most smelt-resistant metallic materials presently available. Replacement of the present generation of Tomlinson black liquor recovery boilers by black liquor gasification cogeneration systems could save the forestry industry 30 trillion Btu annually by 2020. Three industrial partners will cooperate with ORNL in testing the prototypes manufactured from the alloys and, if successful, in helping to commercialize the technology within the forestry industry.

Figure 1.



Ductile Cr-MgO Alloy Bent at Room-Temperature

Project Description

Goal: To develop a new family of chromium-rich alloys resistant to long-term exposure to a molten smelt environment, and with sufficient ductility and toughness to be applied to structural components and/or coatings for gasifier and recovery boiler applications.

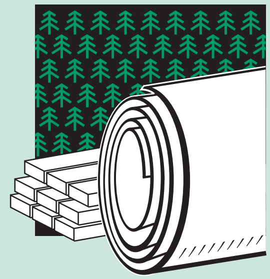
Although pure chromium has excellent high-temperature corrosion resistance to molten alkali salts and good high-temperature ductility, it is usually brittle at room temperature or can become brittle during exposure to nitrogen gases at elevated temperatures. One objective of the project will be to determine the minimum level of chromium needed in an alloy to impart resistance to molten smelt over long periods of time. Another objective will be to improve the mechanical properties and optimize the corrosion resistance of chromium-rich alloys so that they may be used as structural components or coating in the molten alkali salt environments of recovery boilers and black liquor and biomass gasifiers.

Two approaches will be examined for improving mechanical properties: (1) *Oxide dispersion ductilization of microalloyed pure chromium*—It is known that the addition of 2 to 6 percent by weight of magnesium oxide (MgO) to chromium achieves plastic tensile elongation of the material in the range of 10 to 20 percent at room temperature. Additions of microalloys and modification of the MgO addition are expected to reduce the notch and strain rate sensitivity of present Cr-MgO formulations. (2) *Multi-phase, Cr-rich alloys*—A series of chromium-rich model alloys will be assessed to determine the minimum level of Cr needed to withstand long-term exposure to molten smelt. The development will focus on two-phase structures consisting of a tough matrix phase and, to impart smelt corrosion resistance, a Cr-rich second phase.

The smelt for testing new alloy systems will be obtained from a working kraft paper mill.

Progress & Milestones

- AMI has developed and demonstrated wood recovery, recycling, and value-adding technologies for the past 15 years, and currently sells most of the equipment required for the demonstration facility.
- The research effort will take advantage of laboratory-scale infrastructure built for ORNL's previous work on recovery boiler materials and refractory materials for gasifiers.
- Initial experience has shown that corrosion behavior in this smelt immersion system correlates reasonably well with the actual plant environment.
- In year one, there will be a complete assessment of multi-phase, chromium-rich and microalloyed Cr-MgO alloys in molten smelt in the laboratory, and a baseline established for room-temperature mechanical properties (tensile and fracture toughness) of the alloys.
- In year two, successful deposition of Cr-MgO base or Cr-rich alloy coatings will be demonstrated; Cr-MgO or Cr-rich alloy coupons and coated coupons will be prepared for in-plant exposures.
- In year three, the resistance of developed alloys to molten smelt in medium-term (3 to 9 month) in-plant exposures will be evaluated, and efforts will be initiated to manufacture prototype components for evaluation.
- Components manufactured from the developmental alloys will be tested by the cooperating partners—two gasifier suppliers (Babcock and Wilcox along with Chemrec AB)—and a forest product company (Weyerhaeuser).
- If the effort is successful, a materials manufacturer with experience in chromium alloys will be sought.



Project Partners

Oak Ridge National Laboratory
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Babcock and Wilcox
Barberton, OH

Chemrec AB
Stockholm, Sweden

Weyerhaeuser Company
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